

MOLECULAR WEIGHT BY FREEZING POINT DEPRESSION

Introduction:

Once a solution has been formed, the solution displays properties different from those of the solvent used to prepare it. Two common examples of solvent properties that are altered are depression of the freezing point and elevation of the boiling point. The changes in these properties are related to the number of particles present in the solution and not the type of particle present. Properties that depend only on the number of particles are referred to as colligative properties. Colligative properties such as freezing point depression can be used to calculate the molecular weight of a soluble solid. To complete this calculation, the mass of solute and solvent must be known as well as the freezing points of the pure solvent and the solution. In this experiment the molecular weight of an unknown substance will be determined.

Purpose:

The purpose of this laboratory activity is to determine the molecular weight of an unknown compound using the technique of freezing point depression.

Equipment/Materials:

test tube or large vial
foam coffee cup(s)
ice
table salt
temperature probe w/interface and laptop cart
unknown compound labeled as **unknown A**

Safety:

- Always goggles in the lab.

Procedure:

Part I: Freezing Point of Pure Water

1. Obtain a clean, dry test tube or vial. Determine the mass of the test tube or vial. Place about 10 mL of distilled water in the test tube or vial, and reweigh. Record the value.
2. Prepare an ice bath in a foam cup with ice and table salt. Place the cup in a beaker to give it more stability. The ice bath should be deep enough so that it is above the level of the water in the test tube or vial but well below the top. Take care not to let any of the salt or ice get into the sample of distilled water.
3. Place a thermometer or temperature probe in the distilled water. Take time-temperature data every half-minute until ice has formed in the test tube or vial. It is not necessary to freeze the entire sample. Record the temperature at which the sample froze.
4. **Do not** discard the sample of the distilled water, because the sample will be used in Part II.

Part II: Molecular Weight of the Unknown

5. Remove the test tube or vial containing the distilled water from the ice bath. Allow the ice to melt. This step can be speeded up by placing the test tube or vial in a beaker of tap water.
6. Weigh out approximately 1 gram of unknown compound. Add the unknown compound to the distilled water. Reweigh the test tube or vial and record the value. Stir until all of the solid dissolves. Return the test tube or vial to the ice bath. Insert the thermometer or temperature probe.
7. Take time-temperature data as in Part I. Again, the sample does not have to be frozen solid in order to determine the freezing point. Record the freezing point in the data table.
8. Pour the unknown solution into the waste container provided. Rinse the test tube or vial thoroughly with tap water, then rinse with approximately 1 mL of distilled water twice.
9. Repeat the procedure (both Parts I and II).

Prepare a **data table** for two trials, which includes all the data measured.

Calculations:

1. Calculate the mass of water, the mass of unknown compound, and the change in freezing temperature for each trial.
2. Using the change in freezing point, the kilograms of water used, and the freezing point constant for water, calculate the number of moles of unknown compound used in each trial.
3. Using the mass and the number of moles of the unknown compound, calculate the molecular weight for each trial.
4. Calculate the average molecular weight for the unknown compound.
5. Write your names (first initial and last name) along with the molecular weights for your two trials (not the average) on the board. Record the class values, including the names in a table. Calculate the average and standard deviation for the class data. I recommend using Excel for this. If there are outliers, you should remove them and recalculate.
6. Using the class average as the true value, calculate the percent error of your average value.

Conclusion: Report your average molecular weight of the unknown compound and the average and standard deviation for the class. Report the error and if your percent error is more than 1%, comment on sources of error that may have influenced your results. Human error is not an acceptable answer.

Questions:

1. Were there outliers? Based on the standard deviation, do you think the class average is a good estimate of the true value?
2. If you had a percent error of 1% or more, explain how the sources of error you cited resulted in your value being higher (or lower) than the class average.
3. What differences would be expected if an ionic compound such as sodium chloride were used instead of the unknown compound?
4. Why is it not necessary to wait for the entire sample of water to freeze in order to determine its freezing point?

5. Why is it a good idea to measure the freezing point of the water instead of assuming that its freezing point is exactly 0°C ?

6. What would have happened if a two-gram sample of the unknown compound were used in this experiment?